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ON MANAGERIAL INCENTIVES, PERFORMANCE INDICATORS AND EFFICIENCY AUDITS IN PUBLIC ENTERPRISES*

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Abstract:

This article discusses the issues of the selection of performance indicators and the design of efficiency audits in public enterprises following a standard principal-agent model. First, using a well known proposition on the value of information we argue that there must exist a limit to the number of performance indicators employed and that some broadly advocated measures such as productivity indices may be redundant if a well defined (outcome-based) bonus incentive scheme is already in use. Second, following recent theoretical research on managerial accounting we interpret efficiency audits as conditional information mechanisms or costly investigations that are triggered only in specific circumstances, which depend on the extreme realisations of the outcome used to evaluate managerial performance.

1. Introduction

The idea that the internal efficiency of public enterprises could be controlled through performance indicators and efficiency audits was first put forward a long time ago in the United Kingdom (see Robson, 1962, p. 203) and has been discussed by most of

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the official reports of the sixties and seventies. The National Economic Development Office (NEDO, 1976) emphasized the need for the publication by the Boards of the enterprises of a wide range of indicators of performance that was latter accepted by the 1978 White Paper. However, the distinction between indicator and target has not been made clear, nor the control aspects of the introduction of such measures.

Since the 1978 White Paper, a growing body of literature on the sector[1] has stressed the role of performance indicators but included within a framework of comprehensive auditing of public enterprise decisions. The basic idea behind these works is that by making management information systems more transparent to Ministers, external bodies and interest groups (such as consumer councils) the process of control of public enterprises will be greatly improved.

Previous criticism to the ability of audits to solve the managerial control problem have focused on the intrinsic difficulties of making objective and unambiguous recommendations and in the power to enforce such changes once they are suggested (see Schmalensee, 1979 pp. 131-2). The Select Committee on Nationalised Industries (1967/68, Chapter XV paras 777-789) also reflected the criticism –shared by many of the industries at that time– that a system of efficiency audits would interfere excessively with the management of the enterprises. In addition, one could criticize the above mentioned literature on two different grounds: First, it is that they invariably relegate economic efficiency rules to a secondary plane concentrating instead on a huge number of ambiguous indicators. That is, they have started with the idea that financial indicators are incomplete measures of performance and then proposed (in addition) the use of technical measures, neglecting central principles of economic regulation. Second, and equally important, even though they stress questions of management information systems, they also neglect aspects central to the problem of incentives and control –i.e. asymmetries of preferences and information between managers of public enterprises and government officials– in such a way that the effectiveness of the proposed control mechanism seems dubious.

Contrasting with the view of the role of auditing and management information systems held by the previous works, there has been in recent years an explosion in the theoretical research on managerial accounting which has increasingly used developments from the economics of information and thus changed the emphasis from the "decision-facilitating" to the "decision-influencing" aspects of managerial accounting systems (see Demski and Kreps (1982) for a review of the area). The emphasis put on Managers as agents with private information and providing productive inputs explains why the agency paradigm has become a natural instrument of analysis in this area.

The present paper follows this line of inquiry and thus is an attempt to integrate the issues of the selection of performance indicators and the design of efficiency audits into the more general (and broadly defined) issue of the design of information systems and managerial incentive schemes[2] to be used in the control of public firms. Using a standard model of agency for a public enterprise we shall attempt to discuss the rationale for the use of these mechanisms once a "well defined and coherent" system of control has been implemented[3].

The first models of the principal-agent relationship[4] (e.g. Ross (1973)) assumed that managerial activities were completely unobservable and thus ruled out any form of monitoring. Later works recognised that in practice the monitoring technology will not be so underdeveloped and that there will exist some attempts (although imperfect and costly) to monitor managerial activities.

One can identify in the literature at least three types of models or formulations concerned with monitoring in agencies. The first is best represented by the works of Harris and Raviv (1979), Holmstrom (1979) and Shawell (1979) in which the question addressed is when it will be valuable to introduce some costlessly available information on managerial activities, into an efficient (second best) incentive contract. In these models, the decision of whether or not to include such an available signal or monitor becomes *unconditional*, in the sense that its inclusion will not depend on any other event (e.g. the realisation of a particular value of the outcome) but only on its overall valuation. Perhaps the most clear and useful characterization of this decision, is show in Holmstrom's (1979) *informativeness* condition. Roughly speaking, a new or additional signal will be informative if it can tell the principal something more about the possible action chosen by the agent. Thus the important result of these models is that the demand for additional information (on the agent's activities) in an agency is *non-trivial*, that is, a signal must have positive value or be informative.

In section 3 below, we try to relate the informativeness condition to ghe general principles that must guide the selection of performance indicators once a well defined incentive scheme has been implemented. In other words, we ask: Is it valuable to introduce performance indicators into a given incentive contract in order to evaluate and compensate the Manager?

The previous models do not tell us how valuable a given monitor will be nor do they consider the cost of obtaining such an information. Thus, a second type of works have recognized explicity the costs involved in the use of the monitoring technology and therefore suggested ways in which resources can be saved using it occasionally or rather 'conditionally'. Demski and Feltham (1978) and Baiman and Demski (1980a,b) are original representatives of this line of inquiry. In their framework, evaluation systems become *conditional* upon a certain (extreme) realisation of performance by the firm where the expected benefits from calling for an investigation outweigh the costs.

Interpreting efficiency audits as costly investigation procedures to monitor managerial efficiency, it seems that the previous analysis can help us in the discussion of the general principles involving the design and operation of such audits. Thus section 4 below attempts to provide an introduction to such a discussion.

It must be clear however, when we refer to efficiency audits, that we are talking about evaluation mechanisms that try to assess the level of managerial efficiency in the context of a perfect measurement of the outcome or performance. The distinction is relevant since this type of activity is usually known in the literature as monitoring rather than auditing. The usual interpretation of the latter covers not only the evaluation of managerial efficiency but also and more fundamentally an assessment of the level of performance actually achieved. This comes as a result of imperfect observation of performance (e.g. the traditional distinction between reported and actual profits or in our context the inability to observe social benefits) and is the concern of the third class of models discussed. These models (examples are Evans (1980) and Balanchandran an Ramakrishnan (1980)) recognize that auditing is made to assess the actual value of the outcome as well as the level of managerial efficiency, with both seen as joint products of the evaluation system. In this context, the efficiency of any incentive mechanism is obviously lower than in the case of perfect observation of the outcome and it approaches this case as the costs of auditing tend to zero[5].

In the analysis of section 4 however we shall interpret the term efficiency audit as one concerned with the investigation of managerial efficiency in a perfectly-measured-outcome context[6].

Before we deal with the questions of informativeness and performance indicators in section 3 and conditional information systems and efficiency audits in section 4, we shall discuss the formulation of the treatment of incentive contracts, that we shall follow in the present paper.

2. Formulation of the Model: the 'Distribution Function' Approach

The principal-agent relationship has emerged in recent years as a convenient paradigm-example in which to discuss problems of control and incentives. In a broadly used class of these models a risk averse or neutral principal employs a risk (and effort) averse agent to perform a given task. The principal derives utility from the value of an outcome or product –net of the agent's remuneration– which is affected by a random variable and depends positively on the agent's supply of an unobservable (or imperfectly observed) productive input; while the agent derives utility from income and disutility from his work or effort. The central instrument of control is a sharing rule which pays the agent according to the value of the outcome. The literature has been mainly concerned with the derivation and properties of optimal sharing rules that balance gains and losses from incentives and risk sharing. The precontractual information structure in these models is completely symmetrical except for the effort decision (thus the classification of models of moral hazard or pure production incentives); that is, both parties know every relevant functional relationship –including the distribution of random variables– although the principal cannot observe the actual state of nature.

In a previous work (Navajas (1984), Chapter 3) we have studied the properties of a linear bonus scheme designed to solve incentive problems for pricing and capacity – output decisions as well as for the provision of a managerial productive input, under conditions of demand and cost uncertainty. The formulation adopted followed what has been termed the "state-space approach", in the sense that random variables representing uncertainty in the outcome function are treated explicitly, and all distribution functions are unconditional distributions of such random variables. This has been the approach followed in the early literature on agency (e.g. Spence and Zeckhauser, 1971); Ross, (1973); Stiglitz (1974)). In these models the relationship between outcome, the agent's action and the state of nature is considered explicitly, the sharing rule is assumed differentiable and the solution to the optimal non-linear sharing rule is obtained applying the calculus of variations.

This approach has been critically examined by Holmstrom (1978) who noticed that the assumption of the differentiability of the sharing rule employed by the approach may not be valid in a more general context. First, he extended the analysis of a point first made by Mirrless (1974, p. 248) that there may exist no optimal solution for the class of unbounded sharing rules. For this reason one has to restrict the available sharing rules to a finite interval and in these conditions such optimal (restricted) sharing rule may become non-differentiable, invalidating the procedure used by the previous authors. Second, even if the optimal solution exists for unbounded sharing rules, this may become non-differentiable anyway, as an example by Gjesdal (1976) first showed[7].

Furthermore, and perhaps more relevant for our present analysis, while examining the characterization of the optimal non-linear sharing rule made by Ros (1973), Holmstrom recognized the weakness of the state-space approach in (explicitly) considering the impact of the form of the distribution of the random variable upon the optimal sharing rule. This criticism is very important because of the following fact. The distribution of the random variable can be seen as inducing another distribution in the outcome the principal is interested in. Since this distribution is parameterized by the action chosen by the agent, one can interpret the realisation of the outcome as giving some indication, in the traditional bayesian sense, of the actual level of effort chosen by the agent[8]. In this sense, one would expect that the form of the distribution of the random variable would play a central role in the characterization of the optimal sharing rule, but the state-space formulation fails to make this distinction clear.

To overcome these difficulties, another approach originated in the works of Mirrlees (1974, 1976) and extended by Holmstrom has suppressed the random variable from the formulation of the problem and replaced its distribution by the distribution of the outcome parameterized by the agen's action. This method, which may be called the distribution function approach, has proved to be very robust in dealing with the statistical-decision like aspects commented above (see also Milgrom (1981)).

We notice however that our previous treatment can still be justified on two different grounds. First, as it has been recognized by Holmstrom (1978) there exist circumstances, particularly those in which the class of available sharing rules is restricted a priori (say for administrative reasons) to for example the linear class, where the state-space approach is the appropriate formulation to follow. Second, our treatment of the problem of efficient pricing made clear the need to take explicit account of the of random variables associated with demand and cost shocks. This, obviously, would have become obscured suppressing these random variables as in the distribution function approach.

Nevertheless, in dealing with aspects of evaluating alternative information and monitoring systems, the robustness of the distribution function approach suggests that we can benefit from translating our problem into this formulation. In particular this will allow us to make direct use of some central propositions derived under this framework. Also, in order to take full advantage of the methodology we shall work at a general level, studying nonlinear sharing rules, although we shall make references to the linear case whenever possible. Finally, since our prime interest is the study of the monitoring of managerial efficiency we shall not consider the decentralization of pricing or capacity decisions, leaving the treatment as one of pure production incentives. The resulting model is thus equivalent to the case of profit sharing with centralized pricing studied in the previous work.

Let us define the outcome as social welfare $W = S(p) + \pi(p,a,\tilde{s})$, where S is consumer surplus, π profits, p price of the unique good, a managerial effort and $\tilde{s}$ the state of nature (which can be interpreted as cost uncertainty). The incentive contract offered to the Manager is summarized by the sharing rule $y(\pi,m)$ where m is a monitor or information signal that can be introduced into the contract if certain conditions described below are satisfied. We also assume that the sharing rule is bounded above and below $\underline{y} \leq y(\cdot) \leq \overline{y}$.

Define $F(\pi, m; a,p)$ as the joint distribution function of profits and the signal m, parameterized by managerial effort and the price level. (We shall suppress the random variable $\tilde{s}$ and the functional relationship between π, a and p). We further assume that the partial derivative $\pi_a \geq 0$ implying that $F_a = \int\int f_a(\pi, m; a,p)d\pi dm \leq 0$. An increase in effort produces a shift to the right of the distribution function in the sense of first order stochastic dominance. Also we assume that f_a, f_{aa}, f_p and f_{ap}, the partial derivatives of the joint p.d.f. of π and m, all exist and are well defined for every (π, m, a,p). As before, the Minister is assumed risk neutral and thus maximizing the expected value of $W - y(\pi,m)$, i.e. welfare less managerial remuneration. The Manager is assumed risk averse with a separable utility function $U(y,a,) = H(y) - V(a)$, with partial derivatives $H' > 0$, $H'' < 0$, $V' > 0$, $V'' > 0$. Finally we assume that both Minister and Manager have homogeneus pre-contractual beliefs concerning the distribution of the state of nature $\tilde{s}$.

3. Informativeness and the Choice of Performance Indicators

Given the previous notation and assumptions we can write the Minister's problem as:

$$\max_{\substack{y(\pi, m), a, p \\ \underline{y} \leq y(\cdot) \leq \overline{y}}} S(p) + \iint [\pi - y(\pi, m)] \cdot f(\pi, m; a, p) d\pi m \tag{1}$$

subject to

$$\iint H[y(\pi,m)] \cdot f(\pi, m; a,p) d\pi dm - V(a) \geq \hat{U} \tag{2}$$

$$\iint H[y(\pi,m)] \cdot f_a(\pi,m; a,p) d\pi dm = V'(a) \tag{3}$$

Expression (1) simplifies the Minister's objective function to the sum of (deterministic) consumer surplus and expected 'net' profits. Expression (2) reflects the constraint imposed on expected managerial utility given by employment opportunities elsewhere; this constraint is often called the 'rationality' constraint, showing that the Manager will not agree on the incentive contract unless a minimum (autarky) level of utility is guaranteed. Expression (3) is the first order condition of the Manager's choice of a, and it is usually called the self-selection, or incentive-compatibility constraint. We further assume that there exist restrictions in the form of the managerial uutility function and the distribution function $F(\cdot)$ such that the agent's expected utility is concave in effort; thus validating the use of the first order condition approach to model the agent's choice of effort[9]. The Lagrangean function associated with the above problema can be written as

$$L = S(p) + \iint \{ [\pi - y(\pi,m)] + \lambda \cdot H[y(\pi,m)] + \mu \cdot H[y(\pi,m)] \cdot \frac{f_a(\pi,m; a,p)}{f(\pi,m; a,p)} \} f(\pi,m; a,p) d\pi dm - \lambda \cdot V(a) - \mu \cdot V'(a) \tag{4}$$

Pointwise optimization of L with respect to $y(\pi,m)$ gives after some arrangements

$$\frac{1}{H'[y(\pi,m)]} = \lambda + \mu \cdot \frac{f_a(\pi,m; a,p)}{f(\pi,m; a,p)} \qquad \text{for all } \pi, m \tag{5}$$

In addition we obtain two adjoint equations, for a and p respectively which can be written as

$$\iint [\pi - y(\pi,m)] \cdot f_a(\pi,m; a,p) d\pi dm + \mu \cdot \{ \iint H[y(\pi,m)] \cdot f_{aa}(\pi,m; a,p) d\pi dm - V''(a) \} = 0 \tag{6}$$

and

$$S_p(p) + \iint \pi \cdot f_p(\pi,m; a,p) d\pi dm + \lambda \cdot \{ \iint [H[y(\pi,m)] - \frac{y(\pi,m)}{\lambda}] \cdot f_p(\pi,m; a,p) d\pi dm \} + \mu \cdot \iint H[y(\pi,m)] \cdot f_{ap}(\pi,m; a,p) d\pi dm = 0 \tag{7}$$

The characterization given by (5)– (7) is identical to the one shown by Holmstrom (1979) except for the addition of expression (7) which shows the pricing decision taken by the principal. Expression (5) shows the departure from optimal risk sharing[10] that has to be made to attend incentive problems. This departure is proportional to the ratio f_a/f provided that the multiplier μ is positive. This last result follows from Holmstrom's (1979) proposition 1, and it implies that in the second-best equilibrium the Minister would like to see the Manager supplying more effort than the one observed. The ratio f_a/f can be seen as the derivative of the maximum likelihodd function log f with a as an unknown parameter (see, however, note 1). Taking this derivative as monotonically increasing in profits π we assume what has been termed the monotone likelihood ratio property (MLRP), (see Milgrom, 1981)[11]. Under this interpretarion the Minister infers the level of effort put by the Manager from the realization of the outcome π (see next section). In addition, and for a given level of profits, but under different contingencies signalled by m, the ratio f_a/f will be affected implying different remunerations for the Manager. For example, if for one value of m it is possible to infer less about a through the outcome π (i.e. f_a is smaller) than in the absence of the information signalled by m, then the deviation from optimal risk sharing must be correspondingly smaller.

From expression (7) we obtain the optimal pricing rule that the Minister must follow. It shows that when incentive problems are present and the Minister has to introduce an incentive contract to induce the Manager to supply effort, his optimal pricing rule will deviate in general from the rule under full information (Navajas (1984)), proposition 3.1). The first two terms in (7) are respectively the derivatives of consumer surplus and expected profits with respect to price, and lead to the rule under full information (i.e. price equal to expected marginal cost). The second term is associated with the extra compensation that the Manager must receive after a change in price (which induces a change in the degree of profit-uncertainty) to stay at the bargaining utility level. Finally, the third term reflects the effect of a change in price upon the equilibrium, self-selected level of managerial effort.

Turning to the central issues of this section, we shall follow Holmstrom (1979) in defining a signal or monitor m as valuable, if when incorporated into a contract, i.e. y (π,m), both Minister and Manager can be made better off than without the signal, i.e. relying on the contract $y(\pi)$. Thus, a signal m is said to be *informative* about the level of managerial effort if it is *false* that

$$f(\pi,m; a,p.) = g(\pi,m) \cdot (h(\pi; a,p) \tag{8}$$

This condition has a straightforward interpretation in terms of statistical decision theory since it is the condition that π is a sufficient statistic for the pair (π,m) with respect to managerial effort when this is seen as a random variable.

The result obtained by Holmstrom (1979, Proposition 3) is that informativeness is a necessary and sufficient condition for a signal or monitor m to be valuable. The purpose of this section is to use this general principle to discuss the selection (in terms of value of information) of performance indicators –interpreted as monitors– for public firms once an incentive contract has been implemented. There is however a technical aspect of Holmstrom's result that we should mention. The 'necessary' part of the result follows for all types of contracts. However, restricting the class of available contracts beforehand for administrative reasons to for example linear ones the 'sufficiency' part of the result may not be valid in some circumstances. Since this point is rather technical and tangential to the purpose of this section we shall discuss it briefly in the Appendix. For the rest of the section we shall assume that, if informative, a signal m will be valuable even under linear contracts[12]. Notice however that in the discussion below we are more interested in detecting signals that fail to be informative and therefore we are relying on the 'necessary' part of the result.

In this context we have profits as the only outcome in which the Minister can rely to infer the level of managerial effort[13] and we consider additional signals in the form of performance indicators. Those indicators normally mentioned are measures of physical productivity, overhead costs, manning levels, etc., thus we can take m as any of these measures. Nevertheless the standard model of agency used here is too abstract in one fundamental aspect: the variable managerial action of effort is a 'catch-all' concept representing probably numerous activities. Single-valuedness of a is normally assumed for the sake of tractability. However, when it comes to the practical discussion of the usefulness of different specific indicators or signals, it really matters what is the actual form taken by those managerial activities we are trying to monitor. Thus we cannot properly evaluate specific indicator unless we specify in more detail the structure of the problem and in particular the form and nature of the managerial action. For this reason, we prefer to restrict the discussion to two specific examples. In the first, we illustrate a case in which a performance indicator takes the form, of a simple measure of input productivity which is affected by a managerial input.

Example 1. Suppose profits take the following simple form

$$\pi(a,p,\tilde{s}) = p(x) \cdot x(a,\tilde{s},L) - w \cdot L \tag{9}$$

where

$$x(a,\tilde{s},L) = (r + a + \tilde{s}) \cdot L^{\alpha} \tag{10}$$

$x(\cdot)$ is the production function of the firm, L is some input and w the input price. p(x) is the inverse demand function but we shall take p as given or already determined in the next discussion. r is a constant parameter and s is a random variable which for illustrative purposes is assumed to be normal with mean zero and variance σ_s^2. Then profits are distributed as

$$\pi \sim N(p \cdot (r+a) \cdot L^{\alpha} - w \cdot L,\ p^2 \cdot L^{2\alpha} \cdot \sigma_s^2)$$

From (5.9) we can write, dividing by L, and arranging

$$m = \gamma \cdot \pi + \beta \tag{11}$$

where $m = (r + a + \tilde{s}) \cdot L^{\alpha - 1}$ is the average productivity of L and $\gamma = 1/p \cdot L, \beta = w/p$. m is taken as the monitor or performance indicator, and from (11)

$$E\ \{m\} = \gamma \cdot E\{\pi\} + \beta \tag{12}$$

$$\mathrm{Var}\{m\} = \sigma_m^2 = \gamma^2 \cdot \sigma_\pi^2 \tag{13}$$

For notational convenience we shall denote π for (the variable) profits and $\hat{\pi}$ for the number 3.1416. Thus we can write the p.d.f. of π

$$h(\pi; a,p) = \frac{1}{\sigma_\pi \cdot (2\hat{\pi})^{1/2}} \cdot \exp\{-[\pi - E\{\pi\}]/2 \cdot \sigma_\pi^2\} \tag{14}$$

using (11) we can write the p.d.f. of m as

$$k(m,a) = \frac{1}{\gamma \cdot \sigma_\pi \cdot (2\hat{\pi})^{1/2}} \cdot \exp\{-[\pi - E\{\pi\}]/2 \cdot \gamma \cdot \sigma_\pi^2\} \tag{15}$$

or equivalently

$$k(m,a) = 1/\gamma \cdot \exp\{1/\gamma\} \cdot h(\pi; a,p) \tag{16}$$

Since π and m are not two separate random variables we cannot define a joint density for (π,m). Therefore, condition (8) cannot be strictly discussed. Instead, we have a deterministic relationship between π and m in the simple linear form (11). The densities of π and m, both induced by the same random variable $\tilde{s}$ are identical up to a monotonic transform. In this context m does not add any new information about a not already captured by π and one can loosely say that in this sense π is sufficient for (π,m) with respect to a.[14]

This example illustrates a perhaps trivial but nevertheless simple case which I believe may occur in relation to some indicators: they come from the same structure (both stochastic and deterministic) that determines an already used measure of performance, such as profits. The example above assumes the most simple one input-one case but the issue discussed may suffer no loss of generality. In multiproduct-multifactor contexts the usually derived Divisia indices are also closely related to profits (see Crew *et al.*, (1979)) and therefore one would expect a similar result. The next example illustrates a direct monitoring system.

Example 2. Suppose that profits take the form:

$$\pi(a,p,\tilde{s}) = (p - c) \cdot x(p) - q + a + \tilde{s} \tag{17}$$

c is marginal and average variable cost; managerial effort a is seen as activities that reduce the level of fixed costs below q. p is price, assumed given and x(p) is demand. Suppose that the Minister can monitor the level of overhead costs and detect some overspending through a noisy observation of a, that is

$$m = a \cdot \tilde{r} \tag{18}$$

Further, assume that the random variables s and r are independent and normally distribued with mean 0 and 1 and variance σ_s^2, σ_r^2 respectively. Then we can show that

$$f(\pi,m; a,p) = k(m,a) \cdot h(\pi,a,p) \tag{19}$$

In this context m is informative; we further have $\frac{fa}{f} = \frac{ka}{k} + \frac{h_a}{h}$ showing that m is used to infer the level of a in the same way the outcome is. High levels of overhead costs for example will indicate (independently of the level of profits) that overspending is high, that is, a is low. Notice that $\frac{k_a}{k}$ is monotonically increasing in m and $\frac{h_a}{h}$ is monotically increasing in π since the normal distribution satisfies the MLRP. Furthermore suppose the Minister can separate the information provided by m into two disjoint sets M and M^c such that

$$k_a(M,a)/k(M,a) > k_a(M^c,a)/k(M^c,a) \quad \text{where}$$

$k(M,a) = \int_M k(m,a)dm$, $k_a = \int_M k_a(m,a)dm$ and the same corresponding expressions for $k(M^c,a)$ and $k_a(M^c,a)$. In this case the Minister can offer to the Manager a dychotomous contract whereby $y(\pi,M) > y(\pi,M^c)$ for all π, and he uses the information about m only qualitatively, that is just to know whether $m \in M$ or $m \in M^c$. (See also the Appendix for a reference to a linear contract). In other words, despite being remunerated according to profits, the Manager gets an additional prize (penalty) if the level of overhead costs is below (above) a certain amount.

These two examples were not selected in order to exhaust the list of possible cases but to try to illustrate simple and general principles in the discussion of performance indicators. It seems clear that the informativeness condition obtained in the standard principal-agent model has some limitations when one wants to be more specific about a given problem of monitoring. First, the conditions does not tell us how much valuable any given indicator will be nor does it consider the cost of collecting the information. Second, it may not be sufficient even to obtain a positive valuation of a monitor in a context of a priori restricted contracts (cf. the Appendix). In addition the generality of the concept managerial action needs to be substantiated to given an indication of what sort of anomalies we are trying to monitor. Nevertheless, the discussion of this section can provide two teachings of a general character: First, as a prerequisite (necessity), informativeness puts an upper bound to the number of admissible indicators that should be considered for the purpose of monitoring. In term of the actual decision of selecting these indicators this result may cast doubts (shown in example 1) on the efficacy of using a myriad of indices of physical productivity, most of them closely related to each other and to existing measures of performance such as profits. Second, it might be suggested that those indicators which concentrate on specific decisions such as overhead costs, manning levels, etc. can be more useful than general indices, in particular if there is a presumption that unobservable managerial activities are closely linked to those decisions.

4. Conditional Information Systems and Efficiency Audits

Suppose the monitoring technology is such that the Minister can have access to a signal m about the Manager's action only at some positive cost K. This signal can be seen as the product of an investigation or audit mechanism that is costly. If the Minister takes the decision to launch the investigation, m is obtained and K is substracted from the value of the outcome obtained. The gains are of course the information provided by m, in a sense similar to that discussed in the previous section. If, on the other hand, the Minister decides not to launch the investigation, a standard incentive scheme $y(\pi)$, i.e. based on the outcome only, will prevail and the Manager will be remunerated accordingly. How can the Minister design the monitoring mechanism represented by this investigation procedure? In particular, when will he take the decision to investigate, what factors will influence such a decision and to what extent can this decision be used as a threat to influence managerial decisions? The general principles behind the answers to these questions can be of great help in the design and use of efficiency audits in public firms, interpreted as conditional monitoring systems to enforce managerial efficiency. Although the analysis adopted in this section will be restricted to the case where an optimal incentive scheme is implemented, it nevertheless may provide useful insights into questions that have remained unexplored at an analytical level.

Why informativeness is not enough in the present context? The informativeness condition tell us simply that whenever the ratio f_a/f is affected by the signal m, there exists a demand for such signal or information. It does not matter how much noisy m is since this can be eliminated making the sharing rule to depend on m marginally. Thus we eliminate risk effects associated with m and we get only the incentive effects, improving the welfare of both parties. Nevertheless, the presence of positive costs to obtain the signal makes this contract design insufficient to guarantee positive net benefits, since the costs may be higher than the marginal benefits obtained. Therefore, in the context of costly investigation procedures, we need to take into account in a more clear way the *magnitude* of the benefits associated with the use of m.

To begin with, notice that the characterization of the second best sharing rule when m is not used is given by

$$\frac{1}{H'[y(\pi)]} = \lambda + \mu \cdot \frac{f_a(\pi; a,p)}{f(\pi; a,p)} \tag{20}$$

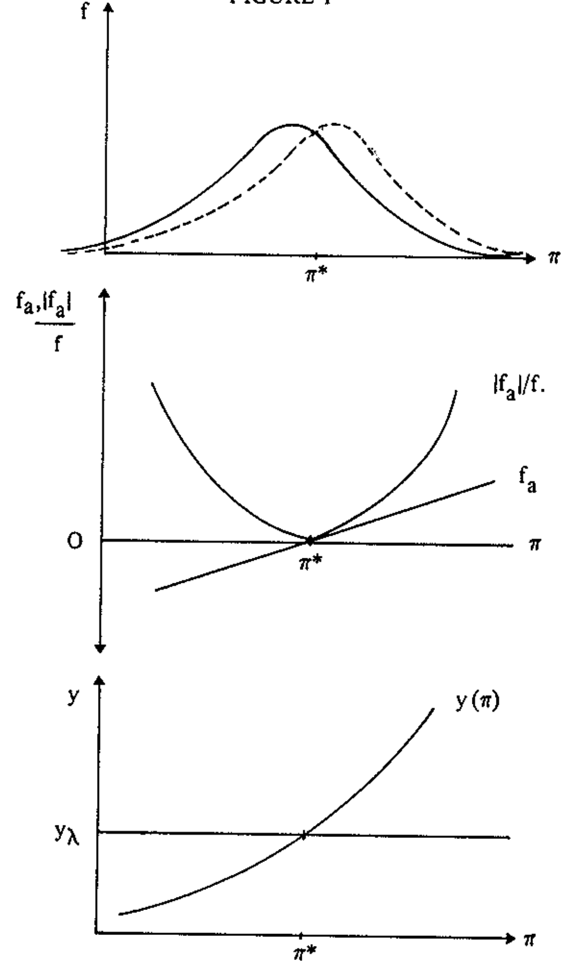
We know that since the ratio f_a/f is generally different from zero for different realizations of π and since μ can be shown to be positive there are gains for departing from the first best (optimal risk sharing) situation. However, notice that since f_a/f is assumed increasing in the outcome π, these gains are greater in the tails of the distribution of π. In other words, starting from the first best situation, characterized by $f_a = 0$, the losses associated with the failure to observe the Manager's action are greater for extreme realizations of π, making the value or demand for information about a higher at these points. Holmstrom (1979, p. 79) gave a clear benefit-cost interpretation to the ratio f_a/f:

> "The characterization in [(20)] has an intuitive interpretation in terms of deviation from optimal risk sharing to provide incentives for increased effort on the part of the agent. This is accomplished by taking $[y(\pi) > y_\lambda]$[15] when the marginal return from effort is positive to the agent[16], and $[y(\pi) < y_\lambda]$ when it is negative... The incentive effect of deviating from optimal risk sharing is stronger the larger is $|f_a|$, and it is more costly (in terms of lost risk-sharing benefits) the greater is f. Thus $|f_a|$, may be interpreted as a benefit-cost ratio for deviation from optimal risk sharing and [(20)] states that such deviations should be made in proportion to this ratio, with individual risk aversion taken into account".

The next figure helps to illustrate the point and it is self-explanatory.

The foregoing discussion thus suggests that the benefits of investigating managerial activities would be higher for extrem realizations of the outcome π, since it is at these

FIGURE 1



values where the departure from the first best situation is the largest one (see also Holmstrom, (1980)). In other words, facing non-trivial costs of launching the investigation, the Minister would call for efficiency audits at very low or very high realizations of profits. A striking characteristic of this interpretation however is that it suggests a pattern (i.e. two-tail investigations) which is different from that most commonly thought in practice, namely that investigations are called when an extremely low (but not high) profit outcome is observed[17]. This however has been one of the main issues studied in the literature, that is, under what circumstances an optimal investigation strategy will adopt a "lower-tail" (or upper-tail) form.

In order to study the form of optimal conditional investigation strategies we shall follow a formulation due to Baiman and Demski (1980a, b). We maintain all the features

described at the end of section 2 except for the incentive contract which is now characterized by the triple $(y(\pi), y(\pi,m), \alpha(\pi))$. The decision to investigate is conditional on the value of profits observed; $y(\pi)$: $\pi \to [\underline{y}, \bar{y}]$ gives the Manager's remuneration when no investigation is performed, $y(\pi,m)$: $\pi x M \to [\underline{y}, \bar{y}]$ his remuneration if the investigation is carried out and a signal m obtained. Finally $\alpha(\pi)$: $\pi \to [0,1]$ can be seen as the conditional probability of investigation given the observation of the outcome. The structure of the decision process associated with the administration of the incentive scheme can be depicted as follows:

Contract specification $(y(\pi, y(\pi,m), \alpha(\pi))$	Act selection by the Manager (price chosen by the Minister)	Outcome observed by Minister and Manager $\pi(a,p,\tilde{s})$	Conditional investigation decision by the Minister $\alpha = \{0,1\}$	Result of the investigations if any m	Payment to the Manager

time →

The Minister's problem is now given by the following program[18]

$$\max_{\substack{y(\pi), y(\pi,m) \in [\underline{y}, \bar{y}] \\ \alpha(\pi) \in [0,1] \\ a}} \iint \{ \alpha(\pi) \cdot [\pi - y(\pi,m) - K] + [1 - \alpha(\pi)] \cdot [\pi - y(\pi)] \} f(\pi,m; a,p) d\pi dm \tag{21}$$

subject to

$$\iint \{ \alpha(\pi) \cdot H[y(\pi,m)] + (1 - \alpha(\pi)) \cdot H[y(\pi)] \} f(\pi,m; a,p) d\pi dm - V(a) \geqslant \hat{U}$$

$$\iint \{ \alpha(\pi) \cdot H[y(\pi,m)] + (1 - \alpha(\pi)) \cdot H[y(\pi)] \} f_a(\pi,m; a,p) d\pi dm = V'(a) \qquad (22)18$$

Since the resulting Lagrange function formed by (5.21)–(5.23) is linear in $\alpha(\pi)$, then this probability will be either zero or one (Baimand and Demski (1980a) Proposition 3). The first order conditions with respect to $y(\pi)$, $y(\pi,m)$ and $\alpha(\pi)$ are, respectively (where λ and μ are the Lagrange multipliers associated with (22) and (23) respectively):

$$(1 - \alpha(\pi)) \cdot [-1 + \lambda \cdot H'[y(\pi)] + \mu \cdot H'[y(\pi)] \cdot \frac{{}_\pi f_a(\pi; a,p)}{{}_\pi f(\pi; a,p)}] = 0 \tag{24}$$

for all π

$$\alpha(\pi) [-1 + \lambda \cdot H'[y(\pi,m)] + \mu \cdot H'[y(\pi,m)] \cdot \frac{f_a(\pi,m; a,p)}{f(\pi,m; a,p)} = 0 \tag{25}$$

for all π,m

$$\int \{ y(\pi) - y(\pi,m) - K + \lambda \cdot H[y(\pi,m)] - \lambda \cdot H[y(\pi)] + \mu \cdot H[y(\pi,m)] \cdot \frac{f_a(\pi,m; a,p)}{f(\pi,m; a,p)} - \mu \cdot H[y(\pi)] \cdot \frac{f_a(\pi,m; a,p)}{f(\pi,m; a,p)} \} f(\pi,m; a,p) dm = 0 \tag{26}$$

for all π

Expressions (24) and (26) result from pointwise optimization over π since the respective instruments are functions of π only; while in expression (25) it is over (π, m). Notice also that in (24) we have integrated over m since the resulting expression does not depend on the signal and therefore the condition is written defining the marginal densities ${}_{\pi}f(\pi; a,p) = \int f(\pi,m; a,p)dm$ and ${}_{\pi}f_a(\pi; a,p) = \int f_a(\pi,m; a,p)dm$.

If the investigation is not launched, i.e. $\alpha(\pi) = 0$, expression (25) vanishes and from expression (24) we obtain the characterization given in expression (20) above. On the other hand, if the Minister launches the investigation, i.e. $\alpha(\pi) = 1$, (24) vanishes and from (25) we obtain the characterization given in expression (5) of section 3. Thus, the central novelty of the model is represented by the decision of whether or not to call for an investigation, summarized in condition (26). From this, Baiman and Demski (1980b) derived the following benefit-cost characterization: $\alpha(\pi) = 1$ if, and only if,

$$B(\pi) = \int \{ y(\pi) - y(\pi,m) + [\lambda + \mu \cdot \frac{f_a(\pi,m; a,p)}{f(\pi,m; a,p)}] \cdot [H[y(\pi,m)] - H[y(\pi)]] \} f(\pi,m; a,p)dm \geqslant K \cdot {}_{\pi}f(\pi; a,p) = C(\pi) \tag{27}$$

Where $B(\pi)$ and $C(\pi)$ are expected benefit and cost respectively of launching the investigation after a given value of π has occurred. On the other hand, $\alpha(\pi) = 0$ if, and only if, $B(\pi) < C(\pi)$. Finally, notice that substituting expression (5) into (27) allows us to write.

$$B(\pi) = \int \{ y(\pi) - y(\pi,m) + \frac{1}{H'[y(\pi,m)]} \cdot [H[y(\pi,m)] - H[y(\pi)]] \} \cdot \frac{f(\pi,m; a,p)}{{}_{\pi}f(\pi; a,p)} dm \geqslant K \tag{28}$$

Baiman and Demski did not provide a detailed discussion of the terms forming $B(\pi)$ but we can see from expression (28) that these benefits are given by the expected value, in terms of m[19], of the sum of the change in the Minister's utility (i.e. $y(\pi) - y(\pi,m)$, since π is given) and a term, in monetary units, reflecting the change in managerial utility, when $y(\pi)$ is substituted by $y(\pi,m)$ as a result of the investigation. Since the outcome of the investigation, i.e. the signal m, is informative about a there will be potential gains from using it to change managerial remuneration, but since m is also noisy there will be a loss due to a further departure from optimal risk sharing. It follows that the main factors affecting the magnitude of $B(\pi)$ will be the degree of accuracy (or noise) assumed for m; the degree of risk aversion displayed by the Manager and finally the shape of the distribution $F(\pi,m; a,p)$ since this will affect the ratio f_a/f which in turn affects the weight $1/H'[y(\pi,m)]$ in (28). Baiman and Demski then move a step further by assuming independence between π and m and thus obtaining a characterization of the optimal investigation policy according to the degree of risk aversion assumed for the Manager. For instance, a 'lower-tail only' investigation strategy follow if the Manager is highly risk averse, since in this case –according to Baiman and Demski– a *noisy* investigation mechanism acts as a punishement and therefore the Manager will try to avoid low realizations of π by increasing his effort (see however Holmstrom's comments (1980)).

Since according to this discussion there exist more than one effect involved in the decision to call for an investigation we will find it convenient to explore a more simple and extreme situation in which the Minister can have access, at a cost K, to a perfect monitoring technology. This analysis can give a complementary perspective to the one provided by the previous authors since they seem to overemphasize the noise rather than the accuracy present in the investigation mechanism.

4.1 The Case of a Perfect Auditing Mechanism

By a perfect auditing mechanism we shall mean an investigation procedure that will give m = a, that is, it will signal the actual level of effort chosen by the Manager. What are the costs and benefits of launching the investigation in this particular case?

Whenever the Minister can have access to the signal m = a we know that the first best situation is attainable with a dychotomous contract of the following form

$$\begin{aligned} y &= y_\lambda && \text{if } a \geqslant a^* \\ &= \phi && \text{if } a < a^* \end{aligned} \tag{29}$$

where ϕ is a penalty and a^* is the first best level or effort. Since the ratio f_a/f in (5.5) becomes zero, since effort is observable, we can compare the marginal utilities $H'[y(\pi)]$ and $H'[y(\pi,m)]$ on the basis of the following equilibrium conditions

$$\frac{1}{H'[y(\pi)]} = \lambda + \mu \cdot \frac{f_a(\pi; a,p)}{f(\pi; a,p)} \tag{30}$$

$$\frac{1}{H'[y(\pi,m)]} = \begin{cases} \dfrac{1}{H'[y_\lambda]} = \lambda & \text{if } a \geqslant a^* \\[2ex] \dfrac{1}{H'[\phi]} = \psi & \text{if } a < a^* \end{cases} \tag{31}$$

where $\lambda > \psi$ and $\psi \to 0$ as a large penalty is imposed on the Manager. Since m = a we can write $B(\pi)$ for the present case as:

$$B(\pi) = \int_{\underline{a}}^{a^*} \{ y(\pi) - \phi + \psi [H[\phi] - H[y(\pi)]] \} \frac{f(\pi; a,p)}{{}_{\pi}f(\pi; p)} da + \int_{a^*}^{\bar{a}} \{ y(\pi) - y_\lambda + \lambda [H[y_\lambda] - H[y(\pi)]] \} \frac{f(\pi; a,p)}{{}_{\pi}f(\pi; p)} da \tag{32}$$

where $\underline{a}$, $\bar{a}$ are the lower and upper values of the set of managerial actions, and we define ${}_{\pi}f(\pi; p) = \int_{\underline{a}}^{\bar{a}} f(\pi; a,p)da$.

The characterization given by (32) has the following interpretation. First, notice that

$\gamma(\pi) = \int_{\underline{a}}^{a^*} \frac{f(\pi; a,p)}{{}_{\pi}f(\pi; p)} da$ and $1 - \gamma(\pi) = \int_{a^*}^{\bar{a}} \frac{f(\pi; a,p)}{{}_{\pi}f(\pi; p)} da$ can be seen as the subjective conditional probabilities (from the Minister's viewpoint) of $a < a^*$ and $a \geq a^*$ respectively, for a given realization of π. Since, by assumption the density $f(\pi; a,p)$ satisfies the monotone likelihood ratio property (MLRP), these conditional probabilities are strongly affected by the particular realisation of π: the higher (lower) is π the lower (higher) is the conditional probability $\gamma(\pi)$[20].

Thus $B(\pi)$ in (32) can be seen again as the expected value of the changes in utility for both parties. Each term within curly brackets shows these changes in the two different sets of values of a ($a \leq a^*$ and $a \geq a^*$) and it is weighted by the subjective probability of that set of values. Notice that the change in managerial utility is weighted differently depending on the value of a in relation to the first best a^*.

In order to give a more precise discussion of the factors affecting the decision to call for an investigation and the form of the optimal investigation policy we can identify three factors affecting the magnitude of $B(\pi)$: 1) The size of the penalty ϕ, 2) the degree of risk aversion displayed by the Manager, and 3) the shape of the probability distribution $F(\pi; a,p)$. We will now discuss each one of these factors in turn.

An increase in the penalty associated with finding the Manager responsible for a low realisation of profits, that is a reduction in the algebraic value of ϕ, will increase the benefits $B(\pi)$, that is

$$\frac{\partial B(\pi)}{\partial \phi} = \{ -1 + \psi \cdot H'[\phi] + \frac{\partial \psi}{\partial \phi} \cdot [H[\phi] - H[y(\pi)]]\} \cdot \gamma(\pi) < 0 \qquad (33)$$

since $\psi \cdot H'[\phi] = 1$ according to (5.31) and $\frac{\partial \psi}{\partial \phi} = -H''[\phi]/H'[\phi]^2 > 0$ and

$H[\phi] - H[y(\pi)] < 0.$

In addition the relative value of ϕ with respect to the value adopted by $y(\pi)$ over the subset $\pi^- = \{\pi: f_a/f < 0\}$, (see Figure 1), is important for the verification of a lower-tail investigation policy. Suppose, as it is likely to be the case in practice, that for extremely low realisations of π, the lower bound y is reached (although one can construct cases in which this will never occur, e.g. see the example in Holmstrom (1979)). In this case, the difference between y and ϕ becomes important for the verification of a lower tail strategy as the next result illustrates.

Proposition 1: Suppose there exists a value $\pi_1 \in \pi^-$ for which the lower bound $\underline{y}$ is reached. If $\phi = \underline{y}$ then we shall not observe a lower tail investigation strategy being followed.

Proof: By the definition of lower tail investigation we have that there must exist an outcome π_o such that whenever $\pi \leq \pi_o$ then $\alpha(\pi) = 1$. By assumption, there exists an outcome $\pi_1 \in \pi^-$ such that

$$\frac{1}{H'[y]} = \frac{1}{H'[y(\pi_1)]} = \lambda + \mu \cdot \frac{f_a(\pi_1; a,p)}{f(\pi_1; a,p)}$$

and $\underline{y}$ is the managerial payment for all $\pi \leq \pi_1$ under the incentive scheme $y(\pi)$. From (32) and since by assumption $\phi = \underline{y}$ we have that the first term dissappears for all $\pi \leq \pi_1$ and

$$B(\pi_1) = \{ \underline{y} - y_\lambda + \lambda \cdot [H[y_\lambda] - H[y]]\} \cdot [1 - \gamma(\pi_1)]$$

The term within curly brackets is independent of π and if it is zero or negative the result follows trivially. If it is positive we notice that $1 - \gamma(\pi)$ is increasing in π, so $B(\pi) < B(\pi_1)$ for all $\pi < \pi_1$. Since $B(\pi)$ decreases with π for $\pi \leq \pi_1$ we cannot find an outcome $\pi_o \leq \pi_1$ such that $B(\pi_o) = K$ and $B(\pi) > K$ for all $\pi < \pi_o$.

Q.E.D.

The importance of this result will of course depend on the verification that the optimal sharing rule $y(\pi)$ is bounded below. If this is the case, Proposition 1 has a clear implication insofar as the required size of the penalty ϕ is concerned, that is we need a penalty which can be set below the minimum salary of the Manager under normal conditions. In some models, $\underline{y}$ is taken as minus the wealth of the Manager and therefore it seems difficult in this context to justify that ϕ can be lower than this amount. In practice however, $\underline{y}$ will be given probably by some institutional constraint (in the form of minimum wage laws, etc.) and in this context the penalty for finding the Manager cheating can be higher than the penalty represented by $\underline{y}$. It might be possible that ϕ is substantially lower than $\underline{y}$, in terms of loss of job, reputation and employment opportunities elsewhere[21].

In order to discuss the role of managerial risk aversion, let us differentiate (30) with respect to π, to obtain after some arrangements

$$y'(\pi) = \frac{\mu}{R_A} \cdot H'[y(\pi)] \cdot \frac{\partial}{\partial \pi}(f_a/f) \qquad (34)$$

where $R_A = -H''[y(\pi)]/H'[y(\pi)]$ is the Arrow-Pratt measure of absolute risk aversion. Expression (34) shows that the slope of the optimal sharing rule $y(\pi)$ will depend on the change of f_a/f with respect to π (which is positive due to the MLRP) and on the degree of absolute risk aversion, for given $H'(\cdot)$ and μ. It also shows that $y'(\pi)$ will depend on π, so linear sharing rules are clearly suboptimal (except for very special cases).

The greater R_A is the lower will be the slope of $y(\pi)$ for a given π and therefore the smaller its departure from the first best schedule vigen by y_λ. This implies, intuitively, that for any outcome $\pi \in \pi^- = \{\pi: f_a/f < 0\}$ the lower will be the increase in income that the Minister will have to grant to the Manager in the event that $m = a \geq a^*$ is shown by the investigation. In addition, the difference between $y(\pi)$ and the penalty ϕ widens, increasing also the potential gains the Minister has in finding the Manager cheating. Thus these effects will make, ceteris paribus, $B(\pi)$ larger for all $\pi \in \pi^-$. A similar argument can show that for all $\pi \in \pi^+ = \{\pi: f_a/f > 0\}$, $B(\pi)$ will be reduced. These effects however ignore the changes in managerial utility taking place which go in the opposite direction (see expression (32)). However, if the Manager is risk averse (and as he becomes more risk averse) changes in managerial utility of income will be lower for those $\pi \in \pi^+$, where income is relatively high, than for those $\pi \in \pi^-$ where it is relatively low. This reasoning implies that we should see a reduction in $B(\pi)$ for $\pi \in \pi^+$ as the Manager becomes more risk averse, but it is less clear about the effect for the subset π^-. The next proposition however makes the analysis neater since it also considers the role of the probabilities $\gamma(\pi)$ and $1-\gamma(\pi)$ neglected in the above discussion.

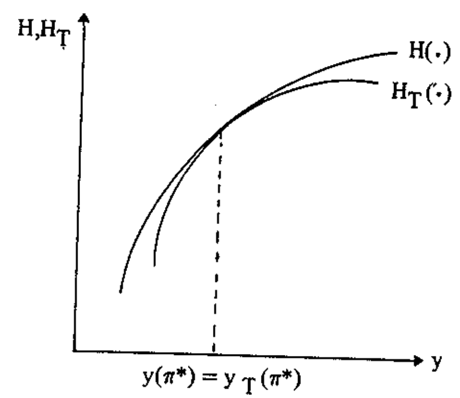
Proposition 2: The value of the benefits $B(\pi)$ becomes lower over π^+ and higher (at least for extreme realisations of π) over π^- as the Manager becomes more risk averse.
Proof: Let $H[y(\pi)]$ denote initial utility (of income) function of the Manager. Let us define an increasing concave transform g of $H[y(\pi)]$,$g:H[y(\pi)] \rightarrow H_T[y_T(\pi)]$. Associated with $H_T(\cdot)$ there will be another optimal sharing rule denoted by $y_T(\pi)$. g is defined so that it has the following properties:

$$H[y(\pi^*)] = H_T[y_T(\pi^*)]$$

and $H[y(\pi)] > H_T[y_T(\pi)]$ For all $\pi \neq \pi^*$ (35)

were π^* is the point where $f_a/f = 0$ (see Figure 1). The next figure illustrates the relationship between $H(\cdot)$ and $H_T(\cdot)$.

FIGURE 2



Thus, it follows that

$$H'[y(\pi)]\left\{\begin{matrix}>\\=\\<\end{matrix}\right\}H'_T[y_T(\pi)] \quad \text{as} \quad \pi\left\{\begin{matrix}>\\=\\<\end{matrix}\right\}\pi^* \qquad (36)$$

Using the equilibrium condition in (5.30) it can be shown that

$$y(\pi)\left\{\begin{matrix}>\\=\\<\end{matrix}\right\} y_T(\pi) \quad \text{as} \quad \pi\left\{\begin{matrix}>\\=\\<\end{matrix}\right\}\pi^* \qquad (37)$$

Thus we have that after the transformation g, $y(\pi)$ increases for all $\pi \in \pi^-$ and decreases for all $\pi \in \pi^+$. To see the impact of this change on $B(\pi)$ let us define, from (5.32),

$$X(\pi) = y(\pi) - \phi + \psi \cdot [H[\phi] - H[y(\pi)]] \qquad (38)$$

$$Z(\pi) = y(\pi) - y_\lambda + \lambda \cdot [H[y_\lambda] - H[y(\pi)]] \qquad (39)$$

thus we can write

$$B(\pi) = X(\pi) \cdot \gamma(\pi) + Z(\pi) \cdot (1 - \gamma(\pi)) \qquad (40)$$

Since the densities $f(\pi; a,p)$ and $_\pi f(\pi; p)$ are unaltered after g, so are the probabilities γ and $1 - \gamma$. Notice that when $\pi \in \pi^+$ we have $f_a/f > 0$ and using (30) and (31) we can sign

$$\frac{\partial X(\pi)}{\partial y(\pi)} = 1 - \psi \cdot H'[y(\pi)] > 0 \qquad \text{For a given } \pi \qquad (41)$$

$$\frac{\partial Z(\pi)}{\partial y(\pi)} = 1 - \lambda \cdot H'[y(\pi)] > 0 \qquad \text{For a given } \pi \qquad (42)$$

Therefore the reduction from $y(\pi)$ to $y_T(\pi)$ reduces both $X(\pi)$ and $Z(\pi)$, and therefore $B(\pi)$, for all $\pi \in \pi^+$.

When $\pi \in \pi^-$ we have that (41) is still valid but (42) has the opposite sign, i.e. $\partial Z(\pi)/\partial y(\pi) < 0$. Thus the increase in $y(\cdot)$ from $y(\pi)$ to $y_T(\pi)$ increases $X(\pi)$ but reduces $Z(\pi)$. However, notice that from (40) we can write

$$\begin{aligned}\frac{\partial B(\pi)}{\partial y(\pi)} &= [\frac{\partial X(\pi)}{\partial y(\pi)} - \frac{\partial Z(\pi)}{\partial y(\pi)}] \cdot \gamma(\pi) + \frac{\partial Z(\pi)}{\partial y(\pi)} \\ &= (\lambda - \psi) \cdot H'[y(\pi)] \cdot \gamma(\pi) + 1 - \lambda \cdot H'[y(\pi)] \\ &= 1 - \eta \cdot H'[y(\pi)]\end{aligned} \qquad (43)$$

where $\eta = y(\pi) \cdot \psi + (1 - \gamma(\pi)) \cdot \lambda$. Since $\psi < \frac{1}{H'[y(\pi)]} < \lambda$ whenever $\pi \in \pi^-$ (i.e. $f_a/f <$ 0, and using expressions (30) and (31)); and since $\gamma(\pi)$ will be high ($(1 - \gamma(\pi))$ low) when $\pi \in \pi^-$, we shall have, at least for extreme realisations of π, $\eta < 1/H'[y(\pi)]$, implying that (43) is positive.

Q.E.D.

As an extreme case, suppose the Manager becomes hugely risk averse, implying that no bonus scheme can be used and thus $y_T(\pi) = y_\lambda$. Then, from (32), we obtain

$$B(\pi) = \{ y_\lambda - \phi + \psi[H[\phi] - H[y_\lambda]] \} \cdot \gamma(\pi) \} \qquad (44)$$

since the term within curly brackets does not depend on π, and $\gamma(\pi)$ is decreasing in π, so is $B(\pi)$.[22]

More generally, the result stated in Proposition 2 provides a useful description of the effect of managerial risk aversion on the form of the investigation policy. It shows that if managerial bonuses have to be a small percentage of managerial income due to the inability of the Manager to take risks, then the chance that the investigation stragegy will be lower-tail increases. A similar effect was obtained by Baiman and Demski (1980b) in the context of a noisy investigation mechanism.

Finally, it is clear from expressions (30) and (32) that the actual shape of the probability distribution $F(\pi; a,p)$ will also play a role in determining the value of $B(\pi)$ over π^- and π^+. This effect will probably depend on the particular form that this distribution will adopt and we have not been able to obtain results of the same level of generality as the previous ones. We notice however two effects of a change in the shape of the density $f(\pi; a,p)$ on the value of $B(\pi)$. First, from expressions (30) and (34) there will be a change in the ratio f_a/f that will affect the form of the sharing rule $y(\pi)$. Second, there will be a change in the conditional probablities $\gamma(\pi)$ and $1-\gamma(\pi)$. The final effect will thus depend on the sign and magnitude of these two effects.

5. Conclusions

In this paper we have attempted to integrate the issues of the selection of performance indicators and the design of efficiency audits into the general framework of managerial incentive schemes discussed elsewhere. The analysis has been made in a highly stylized context and it should be seen only as an introductory step towards a more well-structured and policy-relevant modelling of the issues. However, we believe that some interesting insights, that can guide general principles used in the design of monitoring mechanisms, have been obtained in the course of the analysis.

First we have shown that there must exist, from the viewpoint of the value of information, an upper bound in the number of admissible performance indicators and that some broadly used or advocated measures such as productivity indices may be redundant in some circumstances. In addition, those indicators that concentrate on specific decisions which are presumed to be closely related to unobservable managerial activities can be more useful from an informational viewpoint.

The criticism has been mainly directed to the myriad of equivalent productivity measures proposed in some institutionally oriented literature, but it may have implications as well for the value, as far as "decision-influencing" is concerned, of more sophisticated techniques designed to measure performance in public enterprises. For example, the exercises of "surplus accounting" developed in France and Belgium (see Marchand et al. (1984), introduction) try to decompose changes in profits into changes in quantitives and prices, where the first approximate a productivity measure. Our point is that the value of this decomposition –again, insofar as control is concerned– should not be taken for granted. The idea is well known in modern analysis of managerial accounting (see Baiman and Demski, (1980 b)) but it has passed unnoticed in the discussion of that literature.

Second, a central principle behind conditional informational mechanisms is that since investigations are likely to be costly in practice, we must save resources using them only in specific circumstances. These circumstances are determined according to expected benefits and costs. Thus, following this result we should not observe excessive, day-to-day intervention into the "affairs" of the public firm, but deep investigations only when an extreme outcome occurs. Notice that the justification for this type of policy is not based on the "excessive-intervention-is-bad-for-management" argument used in the debates reflected by official papers and previous specialized writings in the United Kingdom. Instead, it results from a clear expected cost-benefit approach to the use of an information system.

In section 4.1 we studied a perfect auditing mechanism, concentrating on the factors that ffect the optimal form of such a mechanism. We have shown (Proposition 1) that if

the Manager is "safe" from potential penalties that cannot be made effective due to minimum wages or other limited liability institutions, then it will not be beneficial to adopt a lower-tail investigation mechanism, that is, investigations must necessarily carry an implementable punishment in case the Manager is found responsible for low profits. In addition, we have shown (Proposition 2) that as the Manager is less able to take risks and thus to accept contingent payment systems the optimal investigation tends towards the lower-tail form. Thus, designing lower-tail investigation procedures can be an optimal policy under these circumstances.

Appendix

Here we shall briefly discuss why informativeness may not be sufficient for getting a positive value of a monitor when the sharing rule is restricted to the linear class. The strategy followed by Holmstrom (1979) to prove the result under a general sharing rule is (a) to assume that m is informative and to introduce a partition in the set of values of m, M and M^c, such that the ratio f_a/f is higher, on aggregate, in M than in M^c; (b) to choose an additive variation $\delta y(\pi,m)$ in the sharing rule $y(\pi)$, such that $\delta y(\pi,m)$ is constant for all $m \in M$ and for all $m \in M^c$ and satisfies the condition that it equals zero integrated over m, for each given π,a,p; and finally (c) to show that the change in the expected utility of the agent, induced by $\delta y(\pi,m)$, is zero while the corresponding change for the principal is positive.

The problem with linear sharing rules is that the step (b) above may not be satisfied since it may be impossible to find an additive variation satisfying that condition. In notation, this condition (expression (21) in Holmstrom, 1979) is

$$\delta y(\pi,M) \cdot f(\pi,M; a,p) + \delta y(\pi,M^c) \cdot f(\pi,M^c; a,p) = 0 \text{ For all } \pi,a,p \tag{A.1}$$

where

$$f(\pi,M; a,p = \int_{m \in M} f(\pi,m; a,p)dm$$

$$f(\pi,M^c; a,p) = \int_{m \in M^c} f(\pi,m; a,p)dm$$

Let us define the marginal p.d.f. of π,

$$\int_m f(\pi,m; a,p)dm = {}_\pi f(\pi; a,p) = {}^M_\pi f(\pi; a,p) + {}^{M^c}_\pi f(\pi; a,p)$$

thus (5.A.1) can be written as

$$\delta y(\pi,M) \cdot {}^M_\pi f(\pi; a,p) + \delta y(\pi;M^c) \cdot {}^{M^c}_\pi f(\pi; a,p) = 0 \text{ For all } \pi,a,p \tag{A.2}$$

By construction $\delta y(\pi,M)$ is constant over M and $\delta y(\pi,M^C)$ constant over M^C. By linearity the admissible $\delta y(\pi,M) = \delta\alpha_1(M) \cdot \pi + \delta c(M)$ and $\delta y(\pi,M^C)\,\delta\alpha_1(M^C)\cdot\pi+\delta\, c(M^C)$ must be linear in π. In other words $\delta\alpha_1(M), \delta\alpha_1(M^C), \delta c(M)$ and $\delta c(M^C)$ must be constant over π. For this reason it may be difficult to find an additive variation in a linear contract such that (5.A.2) holds for *all* π. Under non-linear sharing rules we work as if we have a different α_1 and c for each π and thus things are easy. Therefore, if (A.2) is not achievable the expected value of the additive variation will be non-zero and there will be non-trivial effects on the utility of the Manager due to risk aversion.

NOTES

1 Examples are Reedwood and Hatch (1982); Likierman (1983) and Aharoni (1983).

2 Like previous treatments of the proporties of managerial incentive schemes for public enterprises (Finsinger and Vogelsang (1982), Gravelle (1982), Navajas (1985)) the spirit of the present work is more normative than positive, since managerial remuneration incentive schemes are rarely used in practice. This is not the case, however, of the use of performance indicators and efficiency audits.

3 By a well defined and coherent control system we understand two things. First that the objectives of the enterprise are clearly defined and thus performance can be measured unambignously. Second, that there exists a corresponding scheme of prize and punishment for managers.

4 Surveys of the principal-agent paradigm can be found in Hess (1983), Macdonald (1984) and Rees (1985).

5 More recently, Baron and Besanko (1984) and Demski, Sappington and Spiller (1986) have studied optimal auditing of regulated firms using the methodology of a group of principal-agent models that stresses asymetric information problems in the transmission of some informative input for a centralized decision (e.g. marginal cost).

6 The evidence available in the U.K. suggests that the meaning of efficiency audits has not been totally clarified in the sense that it involves attempts to evaluate managerial efficiency and to asses performance. This of course comes as a result of the well known difficulties of dealing with performance measurement in public firms and also as a result of more general informational asymmetries between Managers and Ministers. In recent years however the interpretations of efficiency audits have attached much of monitoring (even in the sense of regular monitoring) to the concept, see for example White Paper (1978).

7 In addition, we notice that the problem of uniqueness of the solution to the agent's problem first raised by Mirrlees (1975) and recently examined by Grossman and Hart (1983) and Rogerson (1986) is present in any of the formulations here discussed.

8 This is an interpretation rather than a straightforward application of statistical decision theory, since the agent's action is not a random variable but a variable strategically chosen by an economic agent. Furthermore, given his knowledge of the structure of the problem, the Minister knows exactly what effort the agent will supply for a given sharing rule, see Holmstrom (1980).

9 Rogerson (1986) provides a general treatment of the issue and specifies these required restrictions.

10 Optimal risk sharing is satisfied by the condition that the ratio of marginal utilities of income of principal and agent are equal to a constant, i.e. $1/H'[y(\pi,m)] = \lambda$, see Raiffa (1968).

11 The result that $\mu > 0$ however is obtained without relying on this condition.

12 For this we implicitly assume that the magnitude of the information provided by m makes this possible.

13 Consumer suplus is of course part of the 'outcome' insofar as the pricing decision is concerned; however for the purpose of enforcing managerial efficiency it does not help.

14 The author has been able to obtain an equivalent result when m is measured with an (additive) error $\tilde{t}$, uncorrelated with $\tilde{s}$. Here condition (8) can be discussed strictly, giving $f(\pi, m; a, p) = h(\pi,a,p) \cdot g(t) \cdot J$, where g (t) is the p.d.f. of t and J is a constant.

15 $y\lambda$ denotes the first best sharing rule, where $1/H'[y\lambda] = \lambda$. The difference between $y\lambda$ and $y(\pi)$ mentioned in the text can be proved as a corollary of the proposition that $\mu > 0$, see Holmstrom (1979).

16 This effect can be seen looking at the first order condition of the Manager's choice of a, such as expression (3) where the LHS is the marginal return from effort to the Manager and the RHS the marginal cost.

17 In a similar fashion, sharing rules in the form of profit bonus schemes are commonly bounded from below but it does not appear that they are equally bounded from above.

18 The pricing decision is neglected for the sake of simplicity.

19 Notice that in (5.28) the ratio $f(\pi,m; a,p)/_{\pi}f(\pi; a,p)$ is the conditional probability of m for a given π. Since (5.27) can also be written in this way, the notation $C(\pi)$ is not totally correct since the costs of the investigation do not depend on π but they are fixed at K.

20 This result follows from Milgrom (1981), proposition 1.

21 There is a well known result due to Mirrlees (1974) which establishes that if huge penalties are available, the first best situation can be aproximated arbitrarily. This result is present in this model, since if we can make $\phi = -\infty$ then, for nonprohibitive costs K, the investigation will always be called. In our context, however, the existence of the lower bound $\underline{y}$ prevents the solution from adopting this form.

22 B (π) decreasing in π is a neccesary condition for the lower tail strategy to be optimal; however it is not sufficient. This is the reason why this extreme example is not very helpful: since B (•) will be also negative in this case.

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ESTRUCTURA DE MERCADO, DISTRIBUCION Y CRECIMIENTO

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Abstract:

This paper analyzes the relationship between market structure, income distribution and economic growth in a neo-Keynesian growth model. The microeconomic determination of prices is distinguished from the macroeconomic determination of the rate of return on capital. Two conclusions which depend on this distinction are, first, that an increase in the degree of monopoly (expansion of the oligopolyzed sector) may reduce the rate of growth and reduce the rate of return on capital in the competitive sector, and second, that there may be a significant dispute on income distribution between oligopoly and competitive firms, rather than between wages and capital.

I. Introducción

La idea que los mercados distan mucho de ser competitivos ha adquirido creciente reconocimiento entre los economistas, aunque su incorporación a la teoría económica es todavía parcial. Aún existen muchos interrogantes sobre el efecto de los mercados imperfectos en aspectos claves del funcionamiento de la economía, tales como la distribución del ingreso, la demanda agregada y el crecimiento económico.

Si bien el efecto de los mercados imperfectos es importante en todas las economías de mercado, el fenómeno reviste relevancia en las economías menos desarrolladas, donde la estructura oligopólica es alimentada por factores estructurales tales como el desarrollo industrial relativamente tardío, respecto a los países avanzados, y el menor tamaño del mercado doméstico. En efecto, el desarrollo tecnológico de fines del siglo XIX y

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